Navigator Echo Analysis Hybridizing Magnitude and Phase Edge Detection

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Introduction

Navigator echo can detect respiratory phases by detecting the diaphragm position directly. Thus far, its applicability is limited to the series where the main sequence FOV is distant from the navigator position (e.g., the coronary artery) or repetition time is long (>1s), due to interference of RF pulses between navigator and main sequences. This interference can be reduced by utilization of phase information of a navigator echo but such phase values are influenced by blood signals in the lung. In this study, we developed a hybrid algorithm utilizing both magnitude and phase information to detect the diaphragm position robustly.

Methods

Algorithm

Our navigator echo analysis algorithm uses the edge detection technique for both magnitude and phase data in the navigator pre-scan period, when the patient respiratory information is monitored with a navigator echo data set. In this period, only the navigator echo sequences run and no RF interference occurs. The algorithm consists of the following steps: 1) In the navigator pre-scan period, magnitude data is used to calculate the diaphragm position X_m by the edge detection with threshold method as described in [1]. 2) The edge position X_p is calculated with phase data as well within the narrow range determined by $X_m \pm \Delta X$, where ΔX is a value like 1cm. 3) The end position of expiration is calculated with all the X_p values acquired in the navigator pre-scan period. 4) In the main scan period, the navigator sequence runs between the repetitions of main imaging sequences, and RF interference occurs. 5) In this period, only navigator phase data is used for diaphragm position calculation and edge detection is conducted within the limited range from $X_{ex} - \Delta X_1$ (the lung side) to $X_{ex} + \Delta X_2$ (the liver side), where ΔX_2 is larger than ΔX_1 because the diaphragm moves downwards during inspiration of a patient.

Data Acquisition

We conducted 2D FSPGR with flip angle of 80 degrees as an imaging sequence and navigator echo was incorporated into the sequence for respiratory gating. Cylindrical RF excitation across the right hemi-diaphragm was used for navigator echo sequence. We performed all scans on GE Signa 1.5T HDx/HDe MR imaging systems (GE Healthcare, Waukesha, WI, USA) and informed consent was obtained from volunteers.

Results and Discussion

We compared our hybrid method to the conventional magnitude-based edge detection and phase-based edge detection methods. In the navigator pre-scan period, all the methods detected diaphragm position exactly except for a few edge detection values with phase information (Fig.1b). In the main scan period, the magnitude-based edge detection often fails to acquire the diaphragm position because this algorithm incorrectly detects the dark band edge caused by RF interference (Fig.1a). Phase-based edge detection frequently detected incorrect edge in the lung region because 1) phase values tend to change drastically in the area near receiver coil elements (Fig.2); 2) blood signals in the lung disturb a phase profile. The proposed method limits the search range up to 5cm based on the navigator pre-scan data to eliminate such misdetection and could obtain diaphragm position correctly (Fig.1c). A T1WI was performed with the proposed edge detection method and few artifacts were found with the volunteer who breathed freely (Fig.3).

Conclusion

The new edge detection algorithm with combination of magnitude and phase information was applied to navigator echo analysis and the diaphragm position was measured accurately without RF interference affection. This method can be used to improve the abdominal image quality of the patients who have difficulty in breath hold.

References

1. Du et al., J Cardiovasc Magn Reson 6:483-490 (2004)

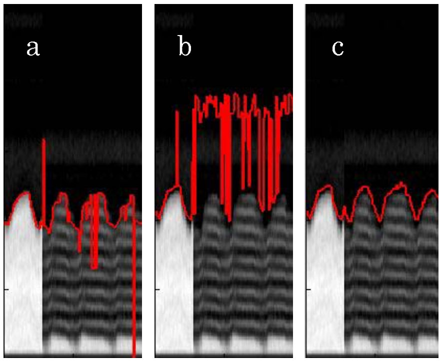

Fig. 1 Navigator echo signals and detected edges (red lines) with a) magnitude information, b) phase information and c) magnitude and phase information.

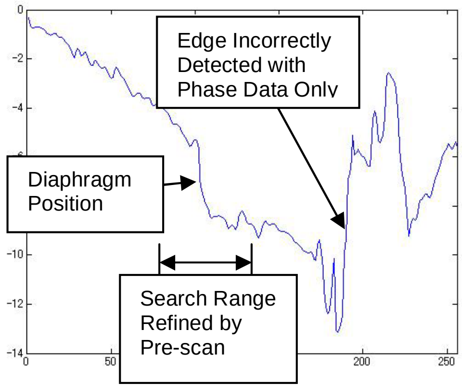

Fig. 2 Typical phase profile of a navigator echo signal. Liver region is on the left side of the diaphragm position.

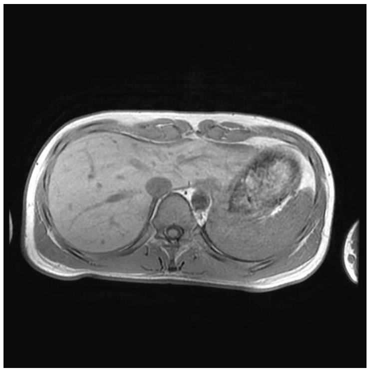

Fig. 3 Respiratory-gated T1 FSPGR with navigator echo using the proposed analysis algorithm (TR/TE=200/4.2).